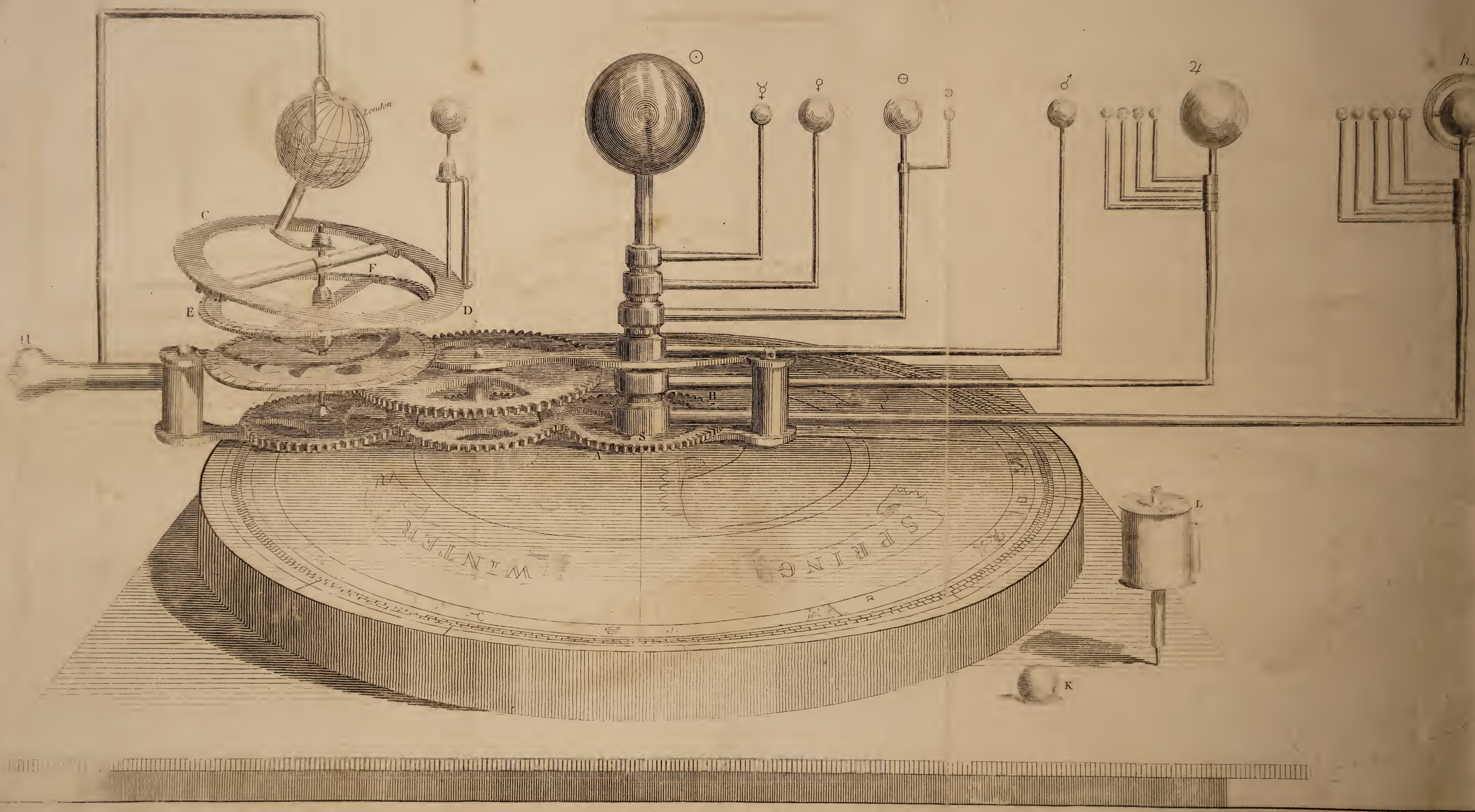

The NEW PORTABLE ORRERY, Invented and Made by WILLIAM JONES.

This Plate shews at one View the manner how either of the two parts of the Orrery is applied to the Board.

☉ *Sun.* ☿ *Mercury.* ♀ *Venus.* ⊖ *Earth.* ☽ *Moon.* ♂ *Mars.* 24 *Jupiter and four Moons.* h *Saturn his Ring and five Moons.*

THE DESCRIPTION AND USE OF A *NEW PORTABLE* ORRERY,

ON A SIMPLE CONSTRUCTION,

REPRESENTING THE MOTIONS AND PHENOMENA OF THE

PLANETARY SYSTEM,

BUT MORE PARTICULARLY THE

MOTIONS OF THE EARTH AND MOON ROUND THE SUN;

FROM WHENCE

THE NATURE AND CAUSES OF THE VICISSITUDES OF THE SEASONS, DAYS AND NIGHTS, SOLAR AND LUNAR ECLIPSES, &c. ARE CLEARLY AND FAMILIARLY EXPLAINED.

TO WHICH IS PREFIXED,

A SHORT ACCOUNT OF THE SOLAR SYSTEM,

OR THE TRUE SYSTEM OF THE WORLD.

WITH FOUR COPPER-PLATES.

The Sixth Edition, with Additions; containing a concise Account of the most recent Discoveries by Dr. Herschel, the new Comets, &c. and the Description of two larger and more complete Portable Orreries.

By WILLIAM JONES,

F. AM. P. S.

London:

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PREFACE.

THE extensive and favourable reception that the Orrery has met with, from persons of the first distinction for abilities and character, has induced me to add, since its original contrivance, several new improvements, in order to give it a greater degree of completeness, and render it still more acceptable to the public.

The two principal additions are, a new engraved plate for the board on which the instrument moves; shewing by inspection the proportional diameters of the planets, distinguished by their proper characters, including the new-discovered planet, and a representation of the appearance of a comet, &c. The other addition is a Planetarium, which screws upon the board in room of that part which represents the Earth and Moon, as shewn in the plate prefixed to this: in fact, I have, as far as simplicity and the smallness of price (which are the two great advantages of the instrument) would permit, endeavoured to complete it for the better excitement and introduction of young ladies and gentlemen to the most pleasing, sublime, and useful of all sciences, *Astronomy*.

The Tellurian part of the Orrery described in the following pages, is constructed nearly upon the principle of one contrived by the late ingenious Mr. *Ferguson;* and its having only four wheels and two pinions, to shew all the phenomena it explains, recommends it to the public for portability and cheapness; particularly to masters and governesses of schools, private tutors, &c. For, by placing

such an instrument in the hands of their pupils, they will acquire by it more knowledge of the useful and interesting parts of astronomy in one day, than by the study of books only, in a considerable time.

I have prefixed a short Account of the Solar System, to prevent the unlearned tyro the trouble and expense of turning over volumes on astronomy, to be informed of that only which no Orreries with conveniency can proportionally represent, *viz.* the diameters, distances, &c. of the primary and secondary planets.

The few lines on the discovery of the new planet, and other recent discoveries, will not, I presume, be unacceptable; as they were inserted for the information of those readers who have no opportunity to peruse the accounts lately published in the Transactions of the Royal Society, &c.

Also are added, an enlarged description of the Moon, with a more accurate engraving of its appearance than I have ever yet met with.

In this Sixth Edition, I have inserted such discoveries of Dr. *Herschel,* &c. as have been made since the former impression; and also the description, with two copper-plates, of two larger and more illustrative Portable Orreries, and appendages, of my contrivance.

And I hope, that it may not be considered as arrogance in my asserting, that this instrument has been the chief means of diffusing a knowledge of the nature of a machine, that formerly was considered the greatest mechanical and admirable curiosity of the age.

THE

DESCRIPTION AND USE

OF A

NEW PORTABLE

ORRERY.

PART I.

A SHORT ACCOUNT OF THE SOLAR SYSTEM.

1. THAT glorious luminary the SUN, the apparent motion of which we daily behold in the firmament, is the center of seven celestial revolving bodies, called primary planets: *viz.* Mercury, Venus, the Earth, (our globe) Mars, Jupiter, Saturn, and the Georgian. These are perpetually and harmoniously moving round the Sun, by the cause of his attractive power, conjoined with a projectile force, or a motion perpendicular to that of the Sun; which may be more easily conceived, from the consideration of the motion of a stone in a sling, where the motion that is given to the sling is the projected force, and the sling that retains the stone from flying off, represents the attractive power of the Sun. The paths that these planets describe are called orbits, and are not exactly circular, but

rather elliptical, and more or less so, in proportion to the combination of the two powers before mentioned.

2. This system of the heavenly bodies, which has the Sun for its center, is generally called the *Solar System*; I shall therefore immediately proceed to give a summary description of the several bodies that compose it, and such particulars of each as are most remarkable; annexing at the same time a concise description of Comets and the Fixed Stars, from the accounts given by modern astronomers, who, to their highest honour and credit, have spared no expense or pains to make new researches and discoveries, and to render the knowledge of the constituent parts of the universe both familiar and easy.

3. The solar system, or the system of the planets, I am now going to describe, is, of all the different systems that have been invented, the most ancient and the most rational to an unprejudiced considerer. We are informed, that it was invented and taught by the famous Greek philosopher, *Pythagoras*, who flourished about 500 years before Christ, and by several of his followers; but afterwards lost in the prejudices of sense and opinion, until about 300 years ago, when it was renewed and supported by the famous Polish philosopher, *Nicholas Copernicus*, a native of Thorn. In this he was followed and confirmed by the most renowned mathematicians and philosophers that have ever flourished, as *Kepler, Galileo, Descartes, Gassendus*, and the incomparable Sir *Isaac Newton*, who has established this system on such a permanent basis of truth and demonstration, as to resist all the efforts of ignorance and error: and from the above philosophers it has received the various names of the Pythagorean, Copernican, and Newtonian System, but now the Solar or true System of the World.

4. There were two systems generally believed at the time of the obscurity of the solar system: one by *Ptolemy*, an Egyptian astronomer, supposed to live 138 years before Christ; the other by a noble Dane, named *Tycho Brahe*, born in Schonen, A. D. 1546.

5. The Ptolemaic System supposed the Earth to be immoveably fixed in the center of the universe, and about which moved the seven planets, *viz.* the Moon, Mercury, Venus, the Sun, Mars, Jupiter, and Saturn; beyond these the firmament of stars; then two crystalline spheres; all of which to receive motion from the primum mobile, or first mover, which revolved about the Earth in twenty-four hours from east to west. But, as this scheme was only agreeable to appearances, and incapable of standing the test of science and observation, it was rejected as a combination of errors and absurdities.

6. The Tychonic System was invented after the Ptolemaic, but was never so general; this supposed the Earth to be the center of the firmament of stars, as also the two luminaries, the Moon and the Sun; but it supposed the Sun to be the center of the planetary motions, *viz.* of Mercury, Venus, Mars, Jupiter, and Saturn. These, with the Sun, revolved about the Earth, to account for the annual or yearly motion; and the Earth revolved about its axis every twenty-four hours, from west to east, to account for the apparent diurnal or daily motion of the heavenly bodies from east to west. This hypothesis, being in part true, and in part false, was embraced by few, and soon surrendered to the only rational or true system restored by *Copernicus**, and demonstrated by Sir *Isaac Newton*, now generally called

* The Tychonic and Copernican Systems may be both familiarly represented in the planetarium part of my portable orrery.

THE SOLAR SYSTEM,

Which has the Sun for its center, and the planets with their satellites or moons revolving round him in the following order, beginning first with

7. The SUN, an immense globe of fire, from which all the planets receive their light and heat, computed to be above 800,000 miles in diameter, and if so, its bulk must be a million times greater than our Earth. When viewed through a telescope, and the eye screened by a dark glass, it has the following appearances: very frequently with black spots on its disc of various forms and numbers; many of the largest are computed to exceed our Earth in magnitude: their duration is for several days, or even months. They are of no constant figure, and frequently divide into smaller ones. They generally consist of a nucleus, or central part, darker than towards the circumference. The common opinion concerning them is, that they are occasioned by the smoke and opake matter thrown out by great volcanos or burning mountains; and that when the eruption is nearly ended, and the smoke dissipated, the fierce flames are exposed, and appear as faculæ or luminous spots. Dr. *Wilson*'s observations seem to prove, that most, if not all of the spots are excavations in the luminous matter that environs the body of the Sun, probably to no great depth.

Dr. *Herschel* conjectures that the Sun may have a luminous atmosphere like that of the Earth, and the black spots to be the body of the Sun seen through the interrupted atmosphere; that it is probably inhabited; that the heat commonly judged to come from it, is not in its rays, but that the rays are the cause of heat, by uniting with the matter of fire contained in the terrestrial substances heated.

By an apparent motion of the spots from east to west, it is proved that the Sun revolves on its axis from west to east in twenty-five days, and that his figure is spherical.

8. MERCURY, the first planet in the system, at the distance of 37 millions of miles; revolves about the Sun in eighty-seven days and twenty-three hours. Its diameter is computed to be 3,200 miles, and its light and heat seven times greater than ours. This planet is but rarely seen, except through a telescope, its apparent situation being at all times near to the Sun, and not farther from it than about 21 degrees, called its *greatest elongation.* Its appearing sometimes like a half moon, larger and smaller, proves its form to be globular, and that it receives all its light from the Sun. The elongation of this planet from the Sun being but small, it is but rarely seen.—Mercury will transit the Sun's disc in November 1815, 1822, and 1835, and in May 1832, 1845, and 1878.

9. VENUS, the second planet, which, at the computed distance of 68 millions of miles, revolves about the Sun in about 224 days 17 hours. Its diameter 7,700 miles, and light and heat twice as great as ours, and is the most brilliant planet of any in the heavens, frequently shewing itself in the day time, and with phases similar to those of the moon; which also proves that it borrows its light from the Sun, and that its form is globular. Its greatest elongation is about 47 degrees.—The next transit of Venus over the Sun's disc, will be in December 1874, and 1882.

10. The EARTH, or that planet on which we live, is the third planet in order from the Sun, and is at the distance of 95 millions of miles from it; its revolution about the Sun is in 365 days, 5 hours, and 49 minutes, moving at the rate of 58,000 miles every hour. This motion causes the Sun to appear to move round in the heavens in

that time; it has also another motion round an imaginary line, called its axis, every twenty-four hours from west to east, which causes an apparent diurnal motion of the Sun and the Heavens together, the contrary way, from east to west: by this swift motion of the Earth on its axis, the inhabitants of London are carried 580 miles every hour, besides the 58,000 miles by the yearly motion beforementioned. The Earth is 7,960 miles in diameter, and is the first planet in the system that is attended by a moon or satellite.

11. The Moon, an attendant of the Earth, revolves about the Earth from change to change in twenty-nine days and twelve hours, at the distance of about 240,000 miles, and is about 2,175 miles in diameter, and therefore about 50 times less than the Earth. From the motions of the Earth and Moon round the Sun, and from the various situations of the Sun, Earth and Moon, in respect to each other, arise the vicissitudes of the seasons, days and nights, eclipses, &c. which, and their causes, the Orrery, hereafter to be described, will evidently represent.

The Moon is to us the nearest luminary of all the heavenly bodies; and, except the Sun the most conspicuous and useful. The accounts by modern astronomers concerning her are, that she is a globular body, similar to our Earth, shining with a borrowed light from the Sun; and in consequence of moving round her axis, in one revolution about the Earth, presents to the Earth always the same face. She is often supposed to contain a kind of human figure; but, in examining her through a good telescope, she affords a most glorious spectacle, and does not appear to have in her any decided or particular form, being diversified with a number of dark and bright parts, with several lucid spots: (see the plate annexed, which is

engraved from observations that I have taken through a two feet and an half best achromatic telescope) a very remarkable one is at the bottom, or near the lower edge, which shines with a steady lustre above the rest, from which proceeds, as it were, streams or streaks of light. This spot is called Tycho by some, and by others, Mount Etna. These several dark and bright spots are judged to be caverns, vallies, and mountains; and, when examined with attention and consideration, give us every reason to believe that she is a body of the same nature with our Earth, and inhabited by various species of animals in various degrees of perfection.

A pleasant and evident proof of the Moon being mountainous may be had, by observing her through a telescope before or after the full; at that part terminating the light and dark parts of her, where, if her surface was even, or none of its parts prominent above the rest, this termination would form a regular or even line; but, on the contrary, it is always observed as it were jagged with innumerable blotches or breaks, and even in the dark part adjoining near the lucid surface, there are seen some small places enlightened by the Sun, clear evidence of hills and mountains in different situations of the Moon in her orbit. These appearances vary, and in all situations the shadows of the elevated parts are found to be in a direction opposite to the Sun, and the cavities are always dark on the side nearest the Sun; every way consistent with what we observe of hills and vallies on our globe.

It may be asked, why the Moon does not appear jagged at her edge, as well as at the confines of her light and dark parts? But let it be considered, that what we call the edge of the Moon's disc is not a single line set round with mountains, if so, it would appear irregularly indented;

but it is a large zone, having many mountains lying behind one another from the observer's eye, so that the mountains in some rows will be opposite to the vallies in others, and therefore fill up the irregularities, so as to make her seem quite round, similar to the appearance of an orange, which, although its roughness may be very discernible on the side next the eye, particularly if the Sun or candle shines obliquely on that side, yet the line terminating the whole visible part will still appear smooth and even. Several astronomers have given us maps of the Moon, which may be met with in the common books upon astronomy, with the figures of the several spots; but in general they are very imperfect, and some seem to have not the least resemblance of the Lunar regions. *Riccioli* divided her among those philosophers and astronomers who had distinguished themselves by that kind of knowledge, applying the most celebrated characters to the largest spots, and those of less repute to the smaller. Afterwards *Hevelius*, who did not approve of this method of distribution, denoted the several parts of the Moon by geographical names belonging to the several islands, countries, mountains, &c. of our Earth, without attending to their situation or figure: but this method not meeting with the general approbation of astronomers, that of *Riccioli* is the one most generally adopted; and accordingly our plate here annexed contains, by the names and numeral figures, references to the several parts as named from the most popular astronomers, philosophers, and mathematicians, by *Riccioli*.

Luminous appearances, or fiery eruptions, have been observed by astronomers, with good telescopes, on the dark part of the Moon, and are judged to be volcanos. In the month of April, 1797, Dr. *Herschel* discovered

A Figure of the Moon with the names of the principal Spots according to Riccioli, Cassini &c.

* *Herschels Volcano*
1 *Grimaldus*
2 *Galileus*
3 *Aristarchus*
4 *Keplerus*
5 *Gaffendus*
6 *Schikardus*
7 *Harpalus*
8 *Heraclides*
9 *Lansbergius*
10 *Reinoldus*
11 *Copernicus*
12 *Helicon*
13 *Capuanus*
14 *Bullialdus*
15 *Eratosthenes*
16 *Timocharis*
17 *Plato*
18 *Archimedes*
19 *Insulasinus Medä*
20 *Pitatus*
21 *Tycho*
22 *Eudoxus*
23 *Aristotles*
24 *Manilius*
25 *Menelaus*
26 *Hermes*
27 *Posidonius*
28 *Dionisius*
29 *Plinius*
30 *Calharina Cyrillus* / *Theophilus*
31 *Fracàstorius*
32 *Promontorium acutum* / *Censorinus*
33 *Meffala*
34 *Promontorium Somnii*
35 *Proclus*
36 *Cleomedes*
37 *Snellius et Furnerius*
38 *Petavius*
39 *Langrenus*
40 *Taruntius*
A *Mare Humorum*
B *Mare Nubium*
C *Mare Imbrium*
D *Mare Nectaris*
E *Mare Tranquilitatis*
F *Mare Serenitatis*
G *Mare Fœcunditatis*
H *Mare Crisium*

three remarkable ones, the account of which is published in the Philosophical Transactions for 1798; one of them exhibited an actual eruption of fire or luminous matter, and on the subsequent night appeared to burn with more violence. The situation of this volcano was somewhat near the spot marked No. 4, Aristarchus, and is represented in the annexed plate of the Moon by a small *.†

12. MARS, the fourth planet from the Sun, at the distance of about 144 millions of miles, circulates about the Sun in 687 days, being about 4000 miles in diameter, and always having a reddish or ruddy aspect. By the spots observed on Mars, its diurnal revolution is ascertained to be in the direction from west to east.

13. JUPITER, the fifth planet, is the largest of all the planets, being no less than 90,000 miles in diameter, and therefore a thousand times bigger than the Earth; revolves about the Sun in about twelve years, at the distance of 490 millions of miles, and is attended with four Moons similar to that of the Earth, their distances and periods being as follow: the first Moon at the distance of 260,000 miles from his center, goes round him in one day, 18 hours and 36 minutes; the second, at 400,000 miles in three days, 13 hours, and 13 minutes; the third, at 650,000 miles, in seven days, three hours, and 59 minutes; and the fourth or last, at 2,000,000 of miles, in 16 days, 18 hours, and 30 minutes.

If this planet be viewed through a common telescope with a magnifying power of about 30 times or upwards, the four satellites may be seen extremely plain, and, if not eclipsed by him, will appear nearly in a right line; thus

† Mr. Russel, a late ingenious artist, from his own telescopic observations, engraved the most accurate representation of the Moon in different ages; and papers to construct a lunar globe, and which we have executed.

the figure below is the position of all four of them, Oct. 25, 1799, at 11 o'clock at night; the small figures denote the order of the moons:

1.

2.  3. 4.

The configurations of these moons are thus given for every night of the year that Jupiter is visible, in the *Nautical Almanack*, a work annually published by the Commissioners of Longitude. In the telescope appearance of Jupiter are observed several obscure long marks or bands, usually called belts, which are constantly regular in their appearance; they are parallel to one another, and to the plane of its orbit. By some it has been conjectured that they are seas; by others, that they are in its atmosphere. There have likewise been observed several large and variable bright spots on the body of this planet. As this is the largest of all the planets, it affords much scope for a curious observer with a telescope of great magnifying power. The times of the eclipses of the satellites, their immersions into, and emersions out of Jupiter's shadow, are likewise given in the *Nautical Almanack* above-mentioned, and in *White*'s *Ephemeris*, books indispensably necessary to every practitioner in astronomy and navigation; particularly *White*'s, when he is using globes or orreries. The eclipses of Jupiter's satellites afford the readiest, and, for general practice, the best method of determining the longitudes of places on land.

14. Saturn, the most distant of the system, being about 900 millions of miles from the Sun, revolves about him in nearly 30 years; its diameter is about 78,000 miles, and it is encircled with a very large ring, at the distance of 21,000 miles, which is also the breadth of the

ring. It is attended by five moons, the distances and periods of which are as follow: the first at the distance of 150,000 miles, goes round him in 1 day, 21 hours, and 19 minutes; the second, at 290,000 miles, in 2 days, 17 hours, and 25 minutes; the third, at 290,000 miles, in 4 days, 12 hours, and 25 minutes; the fourth, at 700,000 miles, in 15 days, 22 hours, and 41 minutes; and the fifth, or last, at one million 900,000 miles, in 79 days, 7 hours, and 40 minutes.

Dr. *Herschel,* in the Philosophical Transactions for 1790, has communicated the account of his discovery, by his large forty feet reflecting telescope, of two new satellites to this planet, which he denominates the sixth and seventh, although they are between that which has hitherto been called the first satellite and the body of the planet: so, in strict propriety, they ought to be called the first and second; but the Doctor adopts the former, to prevent mistakes in the reference to former observations and tables. The periodical times of these moons Dr. *Herschel* observes to be: the sixth, or that nearest Saturn, in 1 day, 8 hours, 53 minutes, and 9 seconds; the seventh, in 22 hours, 40 minutes, and 46 seconds; but the elements of the orbit of this satellite he has not determined with any thing like the accuracy of the former. In the same volume the Doctor has a surmise, that the ring of that planet is composed of two rings nearly in the same plane, if not perfectly so, and concentric to one another, separated only by a very narrow space, appearing to him like a black zone or list on the surface of the ring. But as the planet was, during his observations, in its passage through the node of the ring, and would give a sight of the other side of the ring, he suspended his opinion at that time, and the Transactions of 1792, afterwards communicates the follow-

ing particulars: That, since the time before-mentioned, the southern side of Saturn's ring had become visible, and that he had had several excellent opportunities of viewing that side of the ring to the greatest advantage, and always saw the same black list, at the same distance from the edge of the ring, and of the same breadth, as near as he could judge, that it appeared to be on the northern side; and therefore thinks himself now authorized to say, that the planet Saturn has two concentric rings of unequal dimensions and breadth, situated in one plane, which is probably not much inclined to the equator of the planet. These rings are at a considerable distance from each other, the smallest being much less in diameter than the largest is at the inside.

Belts on the surface of Saturn have been observed through large telescopes, which are parallel to the ring. Saturn is found to revolve on an axis perpendicular to the plane of the ring: the ring itself is inclined to the ecliptic, in consequence of which its apparent figure is continually varying. When the line of its nodes points directly towards the Earth, the ring, presenting its edge to the observer, becomes invisible with common telescopes: if the same line points directly towards the Sun, the ring becomes invisible from defect of illumination; and, if the plane of the ring passes between the Sun and the Earth, it cannot then be seen, because its dark side is towards us: at all other times, its figure is that of an oval, which is broader or narrower, according as the line of the nodes is farther from or nearer to the above positions. In the year 1811, the ring was in the most favourable position for observation: it has been gradually diminishing in view, and in 1818 it will disappear, and afterwards re-appear, shining again in 1825, in the most conspicuous manner.

The period between the fullest appearances or disappearances being about fourteen years.

15. In consequence of a recent discovery, we must now make an addition to our system: several of our present eminent astronomers have proved the existence of a new planet, from some observations made and communicated to them by Dr. *Herschel*, in the Philosophical Transactions for the years 1781, 1782, and 1783; the best account given to us of this discovery is as follows:

" Mr. *Herschel* has for many years applied himself to the constructing of reflecting telescopes for his amusement, and has succeeded so far, that he makes them to bear magnifying powers of an almost incredible bigness, not less than between six and seven thousand times! The effect which these very large magnifying powers had on the appearance of the fixed stars, in shewing many to be double, triple, and even quadruple, which were before thought to be single stars, suggested to Mr. *Herschel* the idea of attempting to discover the parallax of the fixed stars by their means.

" It was in pursuit of this object, that Mr. *Herschel* was examining the small stars near the feet of Gemini, on the 13th of March, 1781, between the hours of ten and eleven at night, when he took notice of one visibly larger than the rest; being struck with its uncommon magnitude, he compared it with H. Geminorum, and the small star in the quadrangle between Auriga and Gemini, and finding it so much larger than they, though not quite so brilliant, began to suspect that it was a comet. To determine this point, he examined it with different magnifying powers, from 722, the power with which he discovered it, to 2010; and found continually, that the diameter of the comet (as he supposed it to be) increased in proportion to

the power, contrary to what is universally known to be the case, when different magnifying powers are applied to the fixed stars; but, in order to obtain absolute certainty in this point, he measured its distance from some of the neighbouring fixed stars, with which he compared it again a night or two afterwards, and then found it was changing its situation at the rate of about $2\frac{1}{4}''$ in an hour.

" Assured of this, Mr. *Herschel* wrote immediately to the Royal Society, informing them of his discovery, that other astronomers might join in the observation of it; but not mentioning, in his first letter, that it was necessary to use a very large magnifying power to distinguish it from a fixed star, they did not immediately discover it. This point being however explained, Dr. *Maskelyn*, the Astronomer Royal, as well as Professor *Hornsby* of Oxford, detected it immediately; and the former, almost as soon as he saw it, declared his suspicions (extraordinary as the case seemed) that it was not one of that species of bodies which we ordinarily call comets, but a planet belonging to our system, of the same nature with the rest, although, on account of its small size and remote situation, it had escaped the observations of astronomers to this time."

The design of this pamphlet will not admit the insertion of the several observations and calculations of other mathematicians and astronomers, which were made in order to determine its revolution, diameter, distance, &c.

" The situation and time of this new planet's motion being determined, astronomers set about calculating the time of its revolution, distance from the Sun, diameter, elements of its orbit, &c. Accordingly, the computations of Mr. *Lexell*, Mr. *De La Lande*, the celebrated French astronomer, and others, make its orbit nearly circular, the time of its revolution 82 years, that it moves at the rate of

43 seconds per day, its apparent diameter about 3 or 4 seconds, its real diameter about $4\frac{1}{2}$ times that of the Earth, and its real distance near 1800,000,000 miles from the Sun."

Mr. *Herschel* concludes his paper on it in the first part of Vol. lxxiii. of the Philosophical Transactions, with "Thus much, however, we may in general surmise, that the diameter of the Georgium Sidus cannot well be much less, nor perhaps much larger, than about four seconds. From this, if we will anticipate more exact calculations hereafter to be made, we may gather that the real diameter of that planet must be between four and five times that of the Georgium Sidus, is stated at 18,913, that of the Earth being 1. And if we take the latter to be seen under an angle of 17″, it would subtend no more than ·898 when removed to the orbit of the Georgium Sidus. Hence we obtain $,\frac{4}{898}$ —4·454, which number expresses how much the real diameter of the Georgium Sidus exceeds that of the Earth;" from which we may infer, that its real diameter is 36000 miles, and its distance 1800,000,000 miles as above.

"This planet appears very small, and when viewed with the naked eye, or a telescope of a small power, is not greatly different from that of a fixed star of the fifth or sixth magnitude, being somewhat less bright than No. 132, of Taurus, in *Flamstead*'s catalogue; but when examined with a good telescope, which magnifies 200 times or upwards, it is far otherwise; as it then appears under a sensible diameter, and its light is more diluted than that of the fixed stars."

The places and motions of this planet are now inserted annually in the Ephemerides before-mentioned.

Dr. *Herschel*, in honour to his present Majesty, has

given it the name of the Georgium Sidus, but it is now more generally called the Georgian Planet.

Further discoveries respecting this planet, and its having six satellites, have been made by Dr. *Herschel.* In the year 1787, he first discovered two; but in 1798, he discovered four more.

The two old satellites he found to revolve, the first in 8 days, 17 hours, 1 minute, 1,5 second, at the distance of 33″ from its primary; and the second in 13 days, 11 hours, 5 minutes, 1,5 second, at the distance of 44″,23. The planes of their orbits form such large angles with that of the planet itself, and consequently to the ecliptic, as to be almost perpendicular to it. To this remarkable dissimilarity to the old planets is added a still more singular one, that *they move in a retrograde direction.* The four new satellites revolve as follow, the periodical times being inferred from their greatest elongations: The interior satellite in 5 days, 21 hours, 25 minutes, at the distance of 25″,5: a satellite intermediate between the two old ones in 10 days, 23 hours, 4 minutes, at the distance of 38″,57: the nearest exterior satellite at about double the distance of the farthest old one, and consequently its periodical time 38 days, 1 hour, 49 minutes: and the most distant satellite full four times as far from its primary as the old second satellite; whence it will take at least 107 days, 16 hours, 40 minutes, to complete its revolution. Whether the motions of these four be direct or retrograde is, I suppose, not yet determined.

Four new planets have recently been announced to us. On the 1st January 1801, Mr. *Piazzi* at Palermo discovered a new planet between the orbit of Mars and Jupiter, which he named *Ceres,* in size about the 8th magnitude of stars; distance from the Sun about $2\frac{1}{2}$ times

that of the Earth. Periodical revolution about 4 years, 8 months. Its diameter about 16,2 miles.

On the 20th March 1802, at Bremen, Dr. *Olbers* discovered a new planet which he named *Pallas*, near the wing of Alirgo. Period of its revolution and distance from the Sun are judged to be nearly the same as Ceres, and diameter 96 miles.

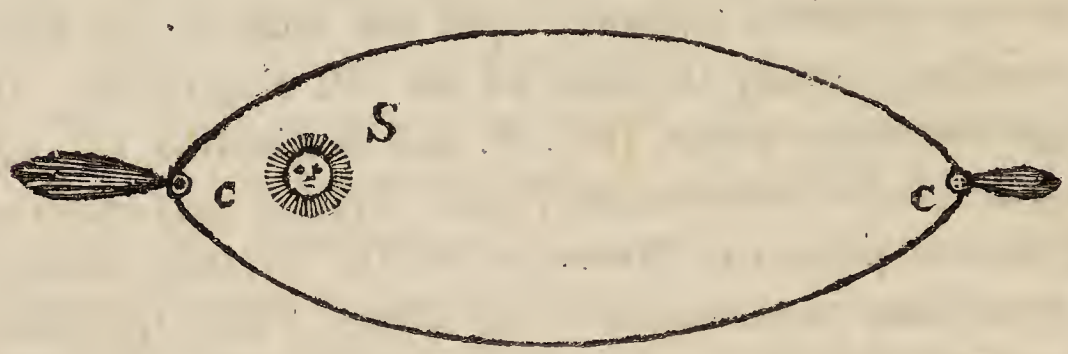
On the 1st September 1804, Mr. *Harding*, of Lilienthul of Bremen, discovered a kind of planet, about the 8th magnitude, which he named *Juno*. This is also judged to be nearly equal in distance from the Sun with the former two; but it has not been stated which are the furthest and nearest.

On the 29th March 1807, Dr. *Olbers* discovered the 4th new planet in distance about the same as the three preceding, similar to a star of the 5th magnitude. Its right ascension about 184°. 8′. and declination 11°. 47′. north. It has been named *Vesta*. Further particulars of these new planets or *Asteroides* as Dr. *Herschel* denominates them, as published by *La Place*, I have translated into my late edition of *Astronomical, &c. Essays*, by the late *G. Adams*, 8vo. 1812.

16. Of all human predictions, those of astronomers are the most infallible, witness their calculating the time of eclipses, transits, periods of the planets, &c. consequently the utmost confidence should be placed in their decisions; and we ought not to discredit the idea of a new planet, or other phenomena, on account of immense distance or imperceptibility in ordinary observations. Telescopes are now made more accurately, and of enlarged dimensions; astronomers are thereby more just and determined in their observations. Besides, it should be remembered that the satellites of Jupiter and Saturn were as much disbelieved

at the time of their discovery, as the existence of another planet and satellite may be at present. Should future observations confirm that they have all the properties of the other planets, we may, without any extent of imagination, receive them into our system, as acting with the rest in the grand celestial exhibition of nature.

17. There is another kind of planets moving round the Sun besides what have been just described, called Comets, which oftentimes appear in every part of the Heavens, cross the orbits of the planets in all manner of directions, and move in very long ovals or eccentric ellipses, the lower focus or center of which is in or near the Sun. Thus in the figure annexed, S represents the Sun in the lower focus of the orbit of the comet c, where, in its nearest dis-



tance from the Sun, it is said to be in its *perihelium*, and in its farthest distance C, in *aphelium*. They are supposed to be solid opake bodies like the planets, and are distinguished from them by long fiery transparent tails or beards, which continually issue from that side of them which is farthest from the Sun; their orbits are of such amazing circumferences, that in some parts of their peregrinations through the Heavens, they approach so near to the Sun, as to be almost vitrified by his heat, and afterwards go off into the regions of infinite space, beyond the orbit of the Georgian, and to such immense distances, as to be considerably deprived of the light and the heat which

the rest of the planets receive from the luminary. According to Sir *Isaac Newton*, the Comet that appeared in 1680, when nearest the Sun, was 2000 times hotter than red-hot iron, and will retain its heat until its return again, which will be in 575 years. This Comet, at its greatest distance from the Sun, was computed to be 11,000 and 200 millions of miles distant, and at its nearest distance, 490,000 miles, moving in its orbit with the velocity of 800,000 miles every hour.

The number of comets belonging to our system is not exactly known; but, from the history of them by ancient and modern astronomers, it is computed that more than four hundred and fifty have been seen previous to the year 1771; and when the attention of astronomers was applied to this object, by the expectation of the return of the Comet of 1759, no less than seven were observed in the course of as many years. From a consideration of this circumstance, and the great probability that all the comets recorded in ancient authors were of considerable magnitude, while the smaller were overlooked, it is reasonable to infer, that the number of comets is considerably beyond any estimation that might be made from the observations we now possess. But, from the opinions of two or three eminent astronomical writers, the number of comets, whose orbits may be said to be determined with sufficient accuracy to ascertain their identity when they appear again, is about fifty-nine. The orbits of most of these inclined in large angles, and the greatest number approached nearer the Sun than the Earth ever does.

In a former edition of this pamphlet, I gave the reader an abstract of the particulars of a Comet whose return was shortly expected, and to make its appearance sometime about the year 1789. Dr. *Halley*, from the

similarity of the elements of the orbits of the Comet observed by *Apian* in 1532, and by *Hevelius* in 1661, judged it to be the same Comet; and of the same opinion were many of our modern astronomers. Dr. *Maskelyne*, the Astronomer Royal, in the *Nautical Almanack* for 1791, in order to set other astronomers distantly situated upon the watch for it, gave an advertisement of its expected return, and also the presumed elements of its orbit. It has not, however, as yet been observed; and, from the imperfect knowledge that we have of the cometary science, and the want of sufficient data to calculate upon, it is uncertain whether the two Comets observed, as before-mentioned, were really the same, or whether the attractions of the planets may have influenced the Comet's path, and thereby changed its time of appearance; whether it has passed unobserved in cloudy weather; or, supposing its path to be changed, whether it may not be one of the comets of smaller magnitude, that within these ten years have been noticed in this kingdom, and by several astronomers abroad.

At the end of the month of September, 1807, a Comet of an extraordinary size appeared in our hemisphere with a considerable nucleus and tail, continued to ascend among the northern constellations, and nightly exhibited itself till the end of the month of November of the same year.

Another Comet of still greater magnitude and brilliancy appeared afterwards at the beginning of August, 1811, with a larger nucleus and tail. It continued ascending and traversing the starry firmament with increasing vividness and augmented tail, till the end of the December following. Its greatest length of tail was nearly 20 degrees, and it is the largest and most remarkable that has visited

as for these 50 years past. More particulars of these two Comets I have given in my last addition of *Adams' Astronomical, &c. Essays,* 1812.

18. The Fixed Stars, which are those luminaries above our heads, that in the absence of our Sun constitute the spangled canopy of the Heavens; and are supposed by modern astronomers to be Suns, made for the same purposes as our Sun, each to bestow light, heat, and vegetation, on a certain number of inhabited planets, kept by gravitation within the sphere of its activity.

19. The number of the stars, including those that can not be seen without the telescope, is infinite; but those that are visible by our naked eyes, limited; for, in a clear winter's night, without moon-shine, there are not to be discerned above 1000, as any person may convince himself by applying to a good celestial globe, where he will see all the stars divided into parcels or constellations, having particular names to each, by which they may easily be distinguished in the Heavens. The white path seen among the stars is called the Galaxy, or Milky Way, and is supposed to be an innumerable quantity of stars, which by their combined lustre cause the white appearance that it is attended with. The distance of the stars from the Earth, and also from each other, is supposed to be immeasurably great; for one of the largest and most brilliant stars in the Heavens, thought to be the nearest of any to us, called Sirius, is calculated to be at no less a distance than 2,200,000,000,000, *viz.* two billions and two hundred thousand millions of miles, and that a cannon ball discharged from the Earth with the velocity of 480 miles an hour, would not arrive at it in less time than 700,000 years. Those stars that appear the largest, and have the greatest lustre, are called stars of the first magnitude; the

next in lustre, stars of the second magnitude; and so on to stars of the sixth magnitude, which are the smallest that can be discerned by the bare eye in a clear star-light night. The vehement twinkling of the stars is occasioned by the tremulous motion of particles in the air; for, the stars appearing like points, will by every intervening opake particle in the air be eclipsed every now and then, so as to cause a scintillation or twinkling; but the planets appearing larger, can suffer no such occultation: hence, here is a certain method of distinguishing the planets from the fixed stars. The apparent daily motion of the stars from east to west arises from the real motion of the Earth on its axis; and the different sets of stars that we see at different times of the year, from the real motion of the Earth in its orbit; (see § 10) both of which are clearly illustrated by the Orrery.

The stars, from accurate observations, are not found to have always the same situations precisely in respect to our globe, and they have also frequent changes among themselves. From the combined action of the Sun and Moon upon the Earth, is found to be produced what is called the precession of the equinoxes, and in consequence, the fixed stars to appear to advance in longitude about 50″ in a year, and since the time of *Ptolemy*, to occasion an advance of near a whole sign, the constellation Aries being situated in that part of the ecliptic denominated Taurus, Taurus in the place of Gemini, &c. as may be observed upon the celestial globe. The complete revolution of the precession of the equinoxes is computed to be in about 25,920 years, and is called the grand Platonic year.

It has been observed that new stars have appeared from time to time, and that several old ones inserted in catalogues are not now to be found. Some of the stars also

are found to have a periodical increase and decrease of magnitude; the most remarkable of these is the star Algol, in Medusa's head: it periodically changes from the first to the fourth magnitude, and the time employed from one greater diminution to the other, was in the year 1783, at a mean 2 days, 20 hours, 49 minutes, 4 seconds.

From recent examination with large telescopes, many of the fixed stars appear double or triple, or to consist of two, three, &c. Dr. *Herschel* has given in the Philosophical Transactions a list of more than 400 of these.

Among the stars are found other phenomena called Nebulæ, or parts of the Heavens with a lighter appearance than the rest. The most conspicuous is the Galaxy, or Milky Way before-mentioned. Other nebulæ are seldom to be distinguished by the eye from small stars; but, when the telescope is applied to them, they appear as luminous spots of various figures, and in some instances with stars in them. The number of nebulæ determined by Dr. *Herschel* is upwards of 500. Many of these are resolvable by the telescope into clusters of small stars, and telescopes of greater light and power resolve these nebulæ into stars, which appear like white clouds in smaller instruments; so that it is reasonable to conclude, that they all consist of clusters, or large masses of stars, at immense distances from our system. There are many other curious and admirable phenomena of the fixed stars, which the reader will find amply described by the writers hereafter referred to.

Accurate representations of portions, upwards of 5000 stars, clusters, planetary nebulæ, &c. the reader will find on the new 18 inch BRITISH GLOBES; the plates for which were recently engraved.

19. " Upon a reflection of the nature and properties of

fixed stars here communicated to us, what an amazing, exquisitely grand, and sublime idea does it afford us of the structure of the universe; not composed of one sun and one world, as the ignorant in astronomy conceive, but consisting of such an inconceivable number of suns, systems, and worlds, dispersed through the infinite abyss of space, that if our sun, with all the planets, moons, and comets, appertaining thereto, were annihilated, they would be no more missed by a person who could survey the whole creation, than a grain of sand from the sea-shore; the space they occupy being comparatively so minute, that it would scarce be a sensible blank in the universe, notwithstanding Saturn, the most distant of all the planets, revolves about the Sun in an orbit of 4884 millions of miles in circumference; and some of our comets make excursions upwards of 10,000 millions of miles beyond Saturn's orbit; and yet at that amazing distance, they are incomparably nearer to the Sun than any of the stars, and return periodically by the efficacy of the Sun's attraction."

20. " And do not thousands and thousands of suns, multiplied without end, and ranged all around us, at immense distances from each other*, attended by ten thousand times ten thousand worlds, all in rapid motion, yet calm, regular, and harmonious, invariably performing the paths prescribed them; worlds peopled with myriads of intelligent beings formed for endless progression in perfection and felicity. Does not this evidently convince us of the existence of a Deity? the superlative greatness, the infinite wisdom, and the paternal goodness of whom, is

* So great are the distances of some of the stars supposed to be, that Mr. *Huygens*, an ancient celebrated astronomer, suggested that the light of many of them had not yet reached the earth since its creation.

most gloriously displayed in this stupendous fabric of the universe."

21. " What an abundance of delight and rational pleasure then is to be obtained by the study and contemplation of the works of the Creator; and how much approbation and encouragement do those contrivances deserve, the design of which is to facilitate such useful knowledge to the understandings of the youth of both sexes? making them both wise and happy; not vainly spending their precious and irrevocable time in the idle and prophane amusements of the age, but enjoying it by researches into the unbounded field of nature; which will unavoidably lead them to confess with the Psalmist, that " 'Tis " God who hath laid the foundation of the earth, and " that the Heavens are the work of his hands."

*** *Those who wish to learn more upon the subject of Astronomy, had best consult the Treatises by the late* G. Adams, 8vo. 1812, *a complete Treatise in English, by the Rev. Mr.* Vince, 2 *vols.* 4to. *just published; and the copious and complete one by* De La Lande, *in French,* 3 *vols.* 4to. 1793.

THE

DESCRIPTION AND USE

OF A

NEW PORTABLE

ORRERY.

PART II.

1. The Orrery consists of two separate machines, what I call a *tellurian* and *planetarium*. The frontispiece is a representation of both these; and, to avoid an additional plate, they are represented as if they were both screwed to the board, whereas only one machine at a time can be used. By the instrument being thus divided into two parts, it becomes much more portable, less expensive, and more completely adapted for the purpose of illustration.

2. That part of the Orrery shewn on the right hand is the planetarium. It represents the Sun in the center, and all the planets and their satellites that move round him, the Georgian only excepted; this being a planet not discernible by the naked eye, I place it only in the larger and best kind of orreries. The characters, in the plate, are placed over each of the planets, and a copy with their names at the bottom of the plate; these the learner should well acquaint himself with, as it will save him much time in rectifying and using the instrument afterwards. The diameter and distances of the planets are not represented in their just and natural proportions, it is not practicable

in any of our confined machines; the learner has had proper information on these points in Part i. § 7, & seq.

3. The left hand side of the plate represents the tellurian, of which the large ivory ball, A, with the circles, denotes the Earth; the small ball, B, the Moon; and the brass ball, ⊙, in the center, the Sun. The wheel-work below is so proportioned, as to give the Moon its proper revolution about the Earth, and the Earth its due position, when both together, by the handle H, are carried round the Sun. The circles, plates, &c. will be hereafter described.

4. The board on which the machines are turned, has pasted on it a printed paper, coloured and varnished; near the outward edge of which are several circles: the first or outward circle is divided into the twelve months of the year, and the next into their respective days; the two innermost circles have the twelve signs of the Zodiac, with their proper characters and names, each sign containing 30 degrees, or the whole 360°: this ecliptic circle represents that path in the Heavens which the Sun seems to describe in a year, though being properly the path of the Earth round the Sun, see Part i. § 10. In this ecliptic circle are four letters, N. W. S. E. signifying the North, West, South, and East parts of the Heavens, as seen from the Earth.

It has also four divisions made by lines drawn from the first degree of Cancer, the first degree of Capricorn, the first degree of Aries, and the first degree of Libra; between these four lines are inserted the four seasons of the year, the lines denoting their beginning, duration, and end; and along these four lines are inserted the length of day and night, and the distinction of the equinoxes.

The inner circle contains a view of the diameters of the planets, in a proportion as near to each other as possible,

and that of a globe of the diameter of the board, for the Sun; the new planet, called the Georgian, is shewn of the comparative size as now estimated, see Part i. § 15; and a small representation of the appearance of a comet.

5. Before I proceed to the description of the Planetarium, it will be necessary to shew how to apply it to the board for use. After taking the Orrery out of the box it usually is packed in, you must take hold of a round turned shoulder or pillar, turned underneath the board, with your left hand, and the wheel, IM, of the frame of wheels, (see the plate) with your right; then turn the board round in a direction from you, or that way which is usual in unscrewing, and that part will be unscrewed; then taking up the Planetarium at the part S, screw it on by the contrary motion of the board that the other was unscrewed by, taking care that it is screwed up quite tight.

6. The Planetarium being now properly fixed to the board, its parts and uses must be attended to as follows:

The ball ☉, in the center, represents the Sun in the center of the system; next are the Planets, Mercury ☿, Venus ♀, the Earth ⊕, and Moon ☽, Mars ♂, Jupiter ♃, and his four Moons, Saturn ♄, his Ring and five Moons; which the learner is now supposed to know by the characters only.

7. The brass ball for the Sun is sometimes taken off the center, and a small tin lamp, L, is placed in the room of it, by a side socket which is made to fit the center arbor.

8. The small brass ball, K, is occasionally placed in room of the Earth ⊕, and the Earth placed on the center instead of the brass Sun. This small brass ball is to represent the situation of the Sun in the Ptolemaic system. See Part i. § 5.

9. The arms of this Planetarium are moved only by the hand, yet the principal phenomena may be thus easily

represented; to the manner of performing of which, we will now proceed, beginning first with a view of the *Ptolemaic Hypothesis.*

10. Place the Earth, ⊕, on the center, in room of the brass ball denoting the Sun, and the small Sun, K, in the place of the Earth; then, by moving Mercury and Venus round the Earth in this system, you will evidently observe the following particulars: 1. That these two planets, being both within the orbit of the Sun, cannot be seen at any time to go behind it; whereas we observe them as often to go behind as before the Sun in the Heavens. 2. It shews that, as the planets move in circular orbits about the central Earth, they ought at all times to be of the same apparent magnitude; whereas, on the contrary, we observe their apparent magnitude in the Heavens to be greatly variable, and so far different, that Mars will sometimes appear nearly as large as Jupiter, and at other times so small, that you can scarce know him from a fixed star. 3. It shews, that any of the planets might be seen at all distances, from the Sun, in the Heavens; or, in other words, that when the Sun is in the west, setting, Mercury and Venus may not only be seen in the south, but even in the east, rising; which positions were never yet seen by any person. 4. You see by moving the planets, that their motions would be always regular and uniformly the same; whereas, on the contrary, we observe them always to move with a variable velocity, sometimes faster, then slower, and sometimes not at all. 5. By moving them as above, the planets move all the same way, *viz.* from west to east, continually; but in the Heavens, we see them move sometimes direct from west to east, sometimes retrograde from east to west, and at other times to be stationary. All which phenomena plainly prove this system to be a false and inconsistent hypothesis.

11. On the contrary, the truth of the *Copernican* or

Solar System, Part i. § 7, &c. which has the Sun in the center and the earth among the planets, is hereby most clearly represented. For, taking the Earth from the center, and replacing it, and putting the large Sun, ⊙, again on the center, then every thing will be right, and agree with celestial observations; for, by moving the planets as before, 1. You will see the planets Mercury and Venus, as viewed from the Earth, go before and behind the Sun, or have two conjunctions. 2. You will observe Mercury, as seen from the Earth, never to be more than 21°, and Venus 47°, from the Sun. 3. That the planets, and especially Mars, will be sometimes much nearer to the Earth than others, and therefore must appear much larger at one time than at another. 4. You will see, that the planets cannot appear at the Earth to move with an uniform velocity; for, when nearest, they appear to move faster, and slower, when most remote. 5. You will observe the planets will appear at the Earth to move sometimes directly from west to east, then to become retrograde from east to west, and between both to be stationary, or without any apparent motion at all; all which correspond exactly with observations, and fully prove the truth of this excellent system. These particulars are exemplified by a simple apparatus adapted to the Portable Orreries.

During the above, we supposed, for clearness sake, that the Earth was motionless, in a line in or near the South, S, of the ecliptic; but the phenomena would happen just the same if the Earth was in motion, their times and duration being only different.

12. These few phenomena of the planetary system lead us to the method of shewing the places and relative aspects of the planets, for any day in the year, to be found by *White*'s Ephemeris, which is published annually by the Stationers Company.

13. The Ephemeris is a diary, or daily account of the places of the planets, as they appear to the eye placed both at the Sun and at the Earth throughout the year, called their *heliocentric* and *geocentric places;* that being the heliocentric place as seen from the Sun, and that the geocentric as seen from the Earth. As an example, for finding the places, we will suppose the Ephemeris at hand, where at the bottom of the left hand page for every month is the heliocentric longitudes, or places, of all the planets, to every six days of the month, which is near enough for common use. A copy of the table is here inserted, for the information of the learner; it is from *White*'s, for March, 1784: now as an example.

Days	Day increas.	Helioc. long. ♄	Helioc. long. ♃	Helioc. long. ♂	Helioc. long. ⊕	Helioc. long. ♀	Helioc. long. ☿
1	3 11	16♑45	17♒11	1♋30	11♍37	0♐35	7♍58
7	3 35	16 56	17 43	4 23	17 37	10 7	25 23
13	3 59	17 7	18 15	7 15	23 36	19 38	11♐59
19	4 23	17 17	18 47	10 6	29 33	29 8	28 33
25	4 47	17 28	19 19	12 55	5♎30	8♑38	15♑49

We will suppose that we want, in order to rectify the Planetarium, the heliocentric places of the planets on the 21st; looking at the table, we take the 19th day, which is the nearest to the day wanted; then the place of Saturn, ♄, is in 17° 17′, or 17° (rejecting the minutes) of Capricornus, ♑; of Jupiter, ♃, in 18° of Aquarius, ♒; of Mars, ♂, in 10° of Cancer, ♋; of the Earth, ⊕, in 29° of Virgo, ♍; of Venus, ♀, in 29° of Sagittarius, ♐; and of Mercury, ☿, in 28° of the same sign; and so on for any other day there specified. Upon this depends a very pleasing astronomical praxis, by which you may at any time be able to entertain yourself in a most rational and agreeable manner; that is to say, you may in a minute or

two represent to yourself the true appearance of the planetary system, just as it really is in the Heavens, and for any day you please, by assigning to each planet its proper place in its orbit; as in the following manner: for the 29th of March, as before, the place of Saturn is in 17° of Capricornus, ♑; now, taking hold of the arm of Saturn, in the Planetarium, I bring it over the 17° of Capricorn on the ecliptic circle of the board; thus, doing the same for the other planets, they will have their proper heliocentric places for that day.

14. Now, in this situation of the planets, we observe, that a person placed on the Earth, would see Venus and Jupiter in the same line and place in the ecliptic; consequently, in the Heavens they would appear together or in conjunction, Mercury a little to the left or eastward of them, and nearer to the Sun; Saturn to the right or the westward, farther from the Sun; Mars directly opposite to Saturn, so that when Saturn appears in the west, Mars appears in the east, and *vice versa*. There are many other aspects evident by the learner's inspection, and if you compare them to the planets in the Heavens, they will be found to correspond exactly; these are the geocentric places. Several other curious and entertaining particulars may be observed, as depending on the above, and easily be represented by the learner, as he increases his progress in astronomy; one in particular is worth noticing: if the Planetarium is set by a white wall, and the lamp placed thereon lighted with oil and a very slender wick of cotton, by moving the satellites of Jupiter and Saturn round the planets, the projection of their shadows will shew the reason why those moons always appear on each side of Jupiter and Saturn in a right line; why those which are most remote appear oftentimes the nearest; and *vice versa*.

15. Thus I have endeavoured to point out to the learner the way of exhibiting the principal and most entertaining phenomena of the planetary system, which may be called the first and fundamental principles of practical astronomy, and prepares the pupil to enter on another useful and interesting part, *viz.* the knowledge of the nature and causes of the vicissitudes of the seasons, days and nights, eclipses, &c. the explication of which is seen by the other part of the Orrery, the Tellurian; the manner of applying which to the board is the same as the Planetarium, and has been already described.

16. The Tellurian being screwed fast to the board, the brass ball in the center represents the Sun as before.

The ivory ball with several circles cut upon it, denotes the Earth, and the brass pin that it is supported on, the axis of the Earth; this brass pin has an inclination of $23\frac{1}{2}$ degrees from a line supposed to be drawn perpendicular to the ecliptic or board, &c. on which it moves round, thereby giving the Earth its proper position, called by astronomers the inclination of the Earth's axis to the plane of the ecliptic. This position never varies, by its axis continuing always parallel to itself; and is therefore termed the Earth's parallelism. It is this invariable position of the Earth that causes the vicissitudes of the seasons, and the different lengths of days and nights, in the Earth's motion round the Sun.

17. The top of the pin on which the Earth turns is called the North Pole, the bottom the South Pole; the two parallel circles near these two poles are termed Polar Circles, the upper one the North Polar Circle, and the under one the South Polar Circle; the two circles next to these are called the Tropics, the upper the Tropic of Cancer, the under the Tropic of Capricorn; the circle in the middle between the poles is called the Equator, be-

cause it equally divides the Earth; for, when the Sun is over that part of the Earth, it is equal day and night all over the globe. There is another circle which crosses the equator, and touches the tropics in two points; this circle represents the path over the Earth that the Sun appears to make in a year, and is called the Ecliptic.

18. There are twenty-four other circles, called Meridian Circles, all meeting at the poles, and crossing those just mentioned; these answer to the twenty-four hours of the day, in which time the Earth turns once round its axis, making one day and one night, as will be explained hereafter.

19. There is a small piece of brass inserted on the Earth, nearly between the upper tropic and polar circles, (see the plate) which represents the situation of London, and by which the various lengths of days and nights, &c. that this metropolis undergoes, are more clearly shewn.

20. The semicircular brass wire that is suspended over the Earth, is called the Terminator, and represents the boundary of light and darkness thereon; for, that half of the Earth on that side of the wire which is next the Sun, is called the Enlightened Hemisphere, and the half on the other side, the Darkened Hemisphere*.

21. The small plain ivory ball denotes the Moon, and is carried round the Earth in $29\frac{1}{2}$ days, by means of the brass arm that communicates with the wheel-work in the frame. For one revolution of the Earth round the Sun, this Moon goes 12 times and one third round the Earth, the same as the Moon in the Heavens. The Moon is fixed on a wire, which moves up and down in a square socket on the arm before mentioned; so that the Moon

* In the larger orreries, another terminating wire parallel to the other at 18 degrees distance behind, is placed to represent the boundary of twilight.

may have her proper inclined motion in respect to the Earth given her by the help of

22. The flat brass open ring, CD, placed under the Earth, which is moveable two ways, *viz.* either horizontally, or vertically; so that when any inclination is given to this ring, or orbit of the Moon, any position of this inclination may be given to it, and by that the exact inclined motion of the Moon in her orbit is represented, as also the Moon's nodes; for, that joint of the ring, where it causes the Moon to begin to ascend above the orbit of the Earth, is called the Ascending Node, ☊, and the opposite joint of the rim the Descending Node, ☋: these two nodes in the Heavens have a retrograde motion through the signs of the ecliptic in 19 years. The true position of them for any particular time may as easily be found as their places in the ecliptic are, by the Ephemeris for the given year; and their places may be set in the Orrery accordingly, by means of another

23. Ring, EF, fixed under the one above-mentioned, having all the signs and degrees of the ecliptic inserted on it; with which the learner is supposed now to be perfectly acquainted, so as to call them by their names when seen. This ecliptic also serves to shew the Moon's place in the Heavens as seen from the Earth, called her Geocentric Place, and also the distance from the Sun that she appears to have at any situation in her orbit; for, this ecliptic, as well as the orbit of the Moon, and the Earth, keeps its parallelism, or all the signs and degrees parallel to those on the board, in its revolution round the Sun.

24. Under the above two circles is a card or plate, which is fixed to the frame of wheels by two screws; this card has the age and phases of the Moon engraved on it, with the initial letters N. M. 1 Qr. F. M. 3 Qr. signifying, that when the wire arm that carries round the Moon

is over any of these letters, it is, according to the letters the wire is over, either New Moon, the First Quarter of the Moon, Full Moon, or the Third or Last Quarter of the Moon. Also when the above arm is over any phase and number, it shews the quantity of light on the Moon that appears to the Earth at the age there figured.

25. The small tin lamp, L *in plate* N, sent with the Orrery, is to be lighted with oil and a very slender wick of cotton, or a small piece of wax taper; then to be placed on the wire that the brass ball denoting the Sun is screwed to, which brass ball must be first unscrewed, and the socket at the bottom of the lamp put on in its room: when the lamp is applied, the room where the Orrery is used should be divested of all other light. This lamp has an excellent effect in using the instrument; for, all the phenomena it is capable of representing, are, as it were, realized by the light of the artificial Sun.

Having thus described the component parts, we now proceed to the use of it, wherein I shall give only a few principal examples; for there are many other particulars to be shewn by it, which will be evident to the learner as he increases his knowledge of astronomy, but could not be included in this small tract.

26. The use of the Planetarium has been already described; the next thing necessary in use, is the Tellurian, and which must be previously rectified by the following means:

At the end of the frame nearest the Sun is a long brass wire serving as an index to point out the several places of the Sun, as he appears to move through by the Earth's annual motion; so that when this index points out the Sun in any particular sign and degree, it is evident that the place of the Earth is in the opposite sign and degree of the ecliptic; as for example, lay hold of the round

shoulder turned on the under side of the board with one of your hands, or place the board steady on a table, and then with the other hand turn the frame of wheels round, by the small ivory handle, H, fixed on the end of the frame farthest from the Sun, till the index points to June the 21st, or to the first degree of Cancer, which indicates that at that time of the year, the Sun appears to be in the beginning of Cancer, and the Earth in the beginning of the opposite sign, *viz.* Capricorn, observing, at the same time, if the signs of Cancer and Capricorn on the board are parallel with the same signs marked on the small ecliptic ring, EF, under the Earth; if not, move the small ecliptic about till they are so: observe also, that the inclination of the Earth's axis is towards the sign of Cancer, and if it is not, move its brass support round the steel wire until it is so; then turn the frame round, until the index points to the day of the month you would rectify it for; as suppose now for June 1st, the index shews that the Sun is then in the 11th degree of Gemini, and consequently the Earth in the 11th of Sagittarius; then looking in an ephemeris or almanack for the given year, for the place or age of the Moon, we find that the place of the Moon is in the 24th of Aquarius, or her age is 20 days, which place or age set in the small ecliptic, see § 23, or the card, see § 24. The place of the Moon's ascending node you will also find in the ephemeris to be in the 13th degree of Aries; you then bring the middle or axis of one of the joints of the flat rim, see § 22, over that degree and sign in the small ecliptic, and elevate the ring in such a manner, that the half of it which is over Aries, Taurus, Gemini, &c. may be about a quarter of an inch higher than the other half, estimating at those parts of the ring that are farthest from the joints, taking care that while the Moon and this rim are setting, the Earth

is kept in the position as before set; then is the Orrery rectified for any past or future time, and is ready to be put in motion. The learner should now understand, that there is not to be expected any calculations by it, its small size not admitting it to be done with any accuracy, being only practicable on the larger orreries, globes, &c.

27. Still keeping the Earth in the same position, turn it round its axis, with your finger, the same way as the order of the signs is; this motion will then represent the daily motion of the real Earth round the imaginary axis in 24 hours, see § 10, Part i. and § 16 of this. As you keep turning the Earth, the brass piece denoting London will, when in the middle of the enlightened half of the Earth, shew that the Sun is then on the meridian, or that it is noon; but, as you keep turning the Earth, London will be brought to the terminating wire, the Sun then to the Londoners is beginning to set; and when London is past the wire, the Sun is quite set, it being to them evening, and consequently in darkness; when it is in the middle of the other hemisphere, it is to them midnight: but, arriving at the other side of the boundary wire, the Sun begins to appear to rise, and London then enters the enlightened hemisphere, called morning; and so on as before. The different lengths of days and nights will be explained in the following sections.

28. While the Earth is carried once round the Sun, by hand, it will exhibit all the beautiful variety of the four seasons. The frame of wheels being moved gently on, according to the order of the months or signs, till the index at the end of the frame points to the 20th of March, or the first degree of Aries, signifying that the Sun on the 20th of March, enters the sign Aries; looking at the Earth, you will now perceive that the equator is opposite to the center of the Sun, or that the Sun is over that part

of the ecliptic which crosses the equator and ascends to the tropic of Cancer, and that the north pole is exactly under the terminator or boundary wire; that the number of circles on each side of the wire is twelve, and by turning the Earth round its axis, you will see there is always that number, and that one half of the Earth is in the light, and the other half in darkness, consequently on the 20th of March there is equal day and night all over the Earth; this is called the Vernal Equinox, and the season of the year called *Spring*.

29. Moving the frame again gently on, you will perceive the north pole to come more and more into the light, and the number of hour circles or meridians between the equator and the north pole contained in the enlightened hemisphere increased, and consequently the length of days at that part of the Earth, those having the longer days who live nearer the pole. Turn the Earth round its axis, and you will see that the situations of London at sun-rising and sun-setting is at the distance nearly of $16\frac{1}{2}$ hours, and at sun-setting to sun-rising about $7\frac{1}{2}$ hours, which is the length of day and night at this time of the year at London, being the 21st of June; and, as the Sun is over that part of the ecliptic which touches the tropic of Cancer, it is to the northern inhabitants the longest day and shortest night, and the middle of that season of the year called *Summer*.

30. Continuing to move the frame on, you will perceive part of the polar circle to retire under the boundary wire until the 23d of September, or when by the index the Sun enters Libra. On that day the position of the Earth is every way the same as it was on the 20th of March, only at this time of the year it is called *Autumn*, or the Autumnal Equinox.

31. Proceed to move the frame on, in doing which the

polar circle will be diminished until the 21st of December, when the Sun enters Capricorn, and is over that part of the ecliptic of the Earth that touches the tropic of Capricorn; when the north polar circle will be entirely in the dark hemisphere, and the quantity of hour circles on the north side of the equator less in the enlightened hemisphere than in the dark hemisphere. The position and affections of the Earth this day are in all respects the reverse of those on the 21st of June, and the time of the year is called *Winter.*

32. Turning the frame till the index points to the 20th of March, the year is then completed, and the position of the Earth is the same as when you first began to move it.

33. Days and nights arise from the daily motion of the Earth on its axis from west to east, as before shewn. The length of days depend upon the time that any part of the globe moves in the enlightened hemisphere; and, on the contrary, the length of nights, by the same place being carried through the darkened hemisphere: now, it will be evident, by moving the frame onward, and looking at the north pole, that you will see it constantly in the light from the 20th of March to the 23d of September, and from the 23d of September to the 20th of March constantly in the dark; which shews, that there is but one day and night at each pole, that they are of six months continuance, and when it is day at the north pole, it is night at the south pole, and *vice versa;* also when it is summer to the northern inhabitants, it is winter to the southern, and the contrary.

34. Continue to move the frame of wheels on the board, and you will perceive, that while the index goes through a month, the Moon will have made just one revolution in her orbit, called a Lunation; in the course

of which lunation, when the Moon is between the Earth and the Sun, she is called a new Moon, as is expressed by the card; when moved a quarter round, in her First Quarter, according to 1 Qr. on the card; when half round, a Full Moon; and, when three quarters round, in her Third Quarter; and so on as before: but, to represent her phases, and also the eclipses more perfectly, we shall suppose the lamp to be lighted and placed on the center of the board, as before directed in the account of the seasons, days, nights, &c. then, as you move the frame on, you will pleasantly see all the phases that the Moon shews herself with, as seen from the Earth, as also her age at any situation in her orbit, expressed by the card before mentioned. This continual change of the Moon's phases demonstrates that she shines not by any light of her own, but receives what she has from the Sun.

35. When the Moon comes between the Earth and the Sun, or is new, her dark side will be towards the Earth, consequently she will not then be visible, unless she eclipses the Sun, which you will see by her shadow falling on the Earth, and the shadow will be high or low on the Earth, according as the Moon is high or low in her orbit. This eclipse is called an eclipse of the Sun, though properly it is an eclipse of the Earth, and all those inhabitants that are and will be in the shadow, will see the sun as eclipsed; and more or less so, as they are farther from, or nearer to, the center of the shadow; from whence it is called either a Total or Partial Solar Eclipse.

36. Turn the frame onward, till the Moon is in the opposite part of her orbit, or is full (for eclipses never happen but about the new or full Moon,) then you will perceive, that all the Moon's enlightened face is towards the Earth, except she falls into the shadow of the Earth; which if she does, there is then a lunar eclipse, or an

eclipse of the Moon, which will be visible to all those inhabitants, that are, and may come into the darkened hemisphere. The eclipses of the Moon are of a longer duration than the eclipses of the Sun; for, the Earth having the greatest shadow, the Moon will take more time to pass through that shadow, than any part of the Earth will to pass through that of the Moon. The duration of total darkness of a lunar eclipse is $1\frac{1}{2}$ hour, sometimes more; but that of a solar eclipse, not above two minutes. The eclipses of the Moon are also more frequent to any one place on the Earth than solar eclipses, because an eclipse of the Moon appears from all parts of the Earth to be the same as it really is; whereas an eclipse of the Sun does not, as you may see by the instrument, but may be total in one part, partial in another, and none at all to others, at the same time. But solar eclipses are more frequent, with respect to the whole Earth, than lunar ones; because the large penumbra of the Moon, which is the fainter sort of shadow surrounding the dark one of the Moon, plainly seen in the instrument, can oftener fall on the large surface of the Earth, than the small globe of the Moon can fall into the conical shadow of the Earth.

37. It may be objected by the young reader, that in this Orrery eclipses almost always happen at every new and full Moon, contrary to what we observe in the Heavens, as they happen there but very seldom; the reason of which may be very easily shewn by the Orrery, by only inclining the flat brass rim (see § 22 of this) as much as the distance of it from the small ecliptic will admit; then by turning the frame on the board, you will perceive that eclipses will not happen at every new and full Moon, but only while the Moon is in, or near those two parts of her orbit called the Nodes, see § 22 of this.

38. If you make a small spot with ink or a pencil on the

ivory ball denoting the Moon, facing the Earth, and then move the frame round on the board, you will observe that she will, in her course round the Earth, still keep the same face towards it, the same as the Moon in the Heavens always shews the same face towards the Earth, or to us. Upon a consideration of the motion shewn in the instrument, the reason of her keeping the same side towards the Earth will appear; and that consequently to produce this, she turns once round her axis, exactly in the time she goes round the Earth, and that her day and night together are as long as our lunar month, and also that those inhabitants on the farthest side of the Moon, if any there be, can never have the sight and enjoyment of the light of our Earth.

The reader, from what has been described, must perceive that this small instrument is not intended to assist in calculations for exact time, true and proportional positions, &c. but to exemplify and explain such of the principal phenomena of the Heavens as arise from the respective aspects, motions of the planets, and the manner in which they receive their light from the Sun, &c. It is only on large orreries and globes, that problems may be worked, so that their result may agree with numerical calculations.

I have more particularly endeavoured to elucidate and explain, by this PORTABLE ORRERY, those general and useful particulars in astronomy, that are frequently subjects of conversation; and wherein young persons, for the want of consulting such an instrument as this, often find themselves greatly embarrassed: it may likewise serve as a stimulus to the young and rational mind, to attain more knowledge of this truly great and sublime science.

AN

APPENDIX,

CONTAINING THE DESCRIPTION OF A LARGER AND MORE ILLUSTRATIVE PORTABLE ORRERY, SHEWING THE MOTIONS OF THE EARTH, MOON, AND INFERIOR PLANETS, BY WHEEL-WORK.

THE Planetarium part of the Orrery described in the preceding pages, requires the respective planets to be moved, and set in their heliocentric places in the ecliptic by hand; and also in its application to the board, the trouble of unscrewing off the Tellurian, and screwing on the Planetarium. Orreries therefore are the more complete, according as all the periodical and diurnal revolutions are shewn by wheel-work, at one operation, and in one entire machine. In proportion to the quantity of wheel-work and the dimensions of these machines, the expenses we make them at, are various and considerable; and, until a few years ago, when I contrived the Portable Orrery, the large Orrery was as elaborate and expensive an article, as it was a rare and admirable curiosity. The reader will see, by the list of prices affixed, the reduced prices at which we now make them; and the instrument I am proceeding to describe is made but at a small expense more than the other described in the preceding pages, and packs up into a case very little larger, of the dimensions of only fourteen inches square and eight inches deep.

Fig. 3.

Fig. 2.

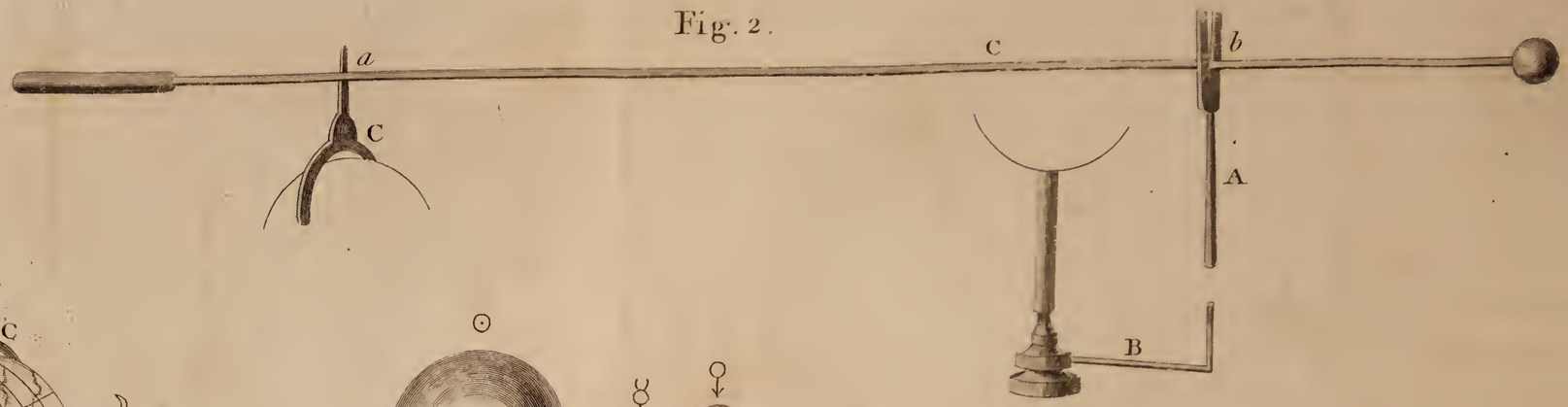
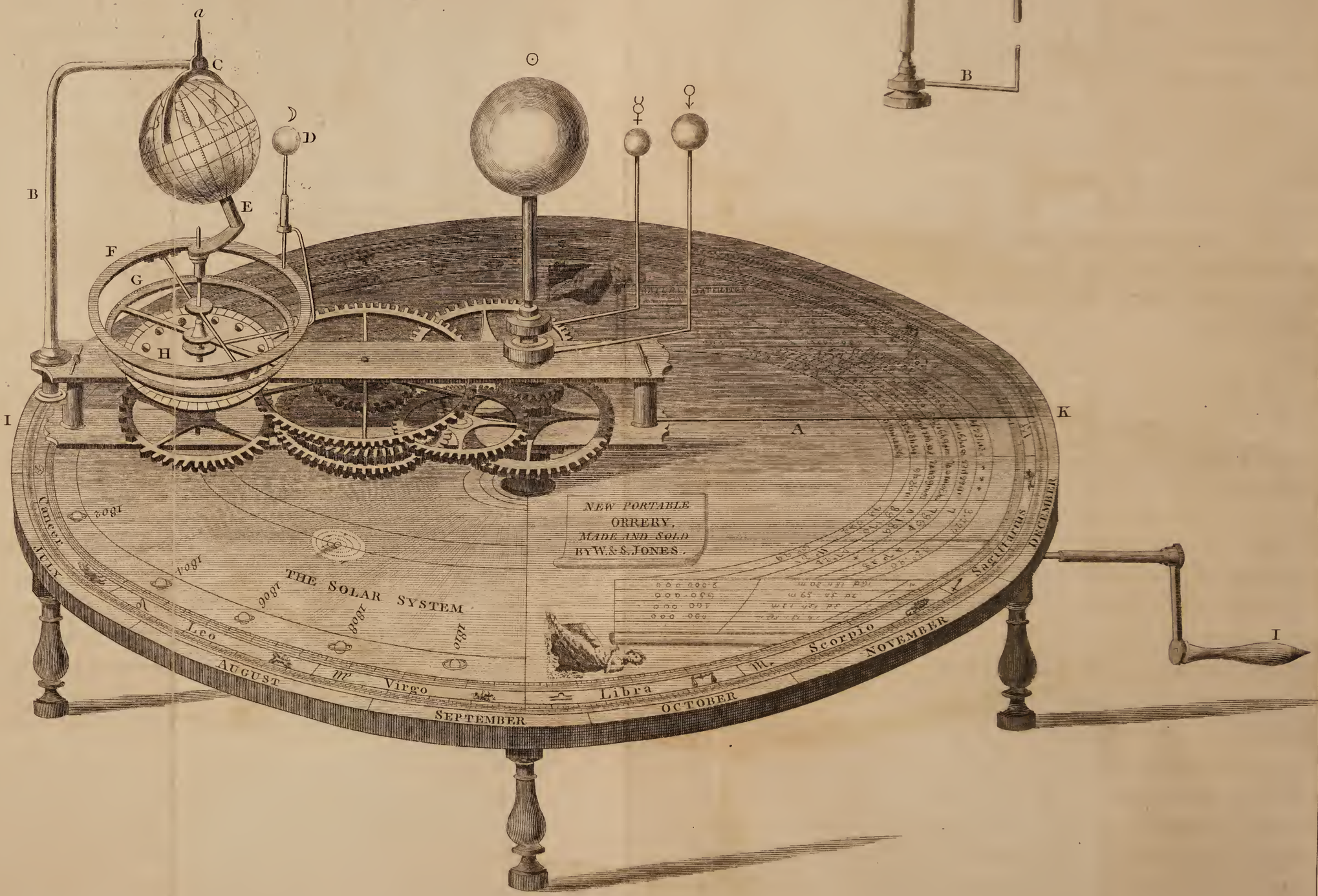


Fig. 1.



London. *Printed for & Published by* W. & S. Jones, *135 Holborn as the Act directs, 1st March 1799.*

Plate 2, fig. 1, represents the Orrery placed on a table ready for use. The brass ball, ☉, in the center represents the Sun: the nearest ivory ball, ☿, the planet Mercury, which by the wheel-work below is carried round the Sun in about 87 days: the next ivory ball, ♀, represents Venus, which also by the wheel-work performs her revolution in about 224 days: the new ball or papered globe, ⊕, is the Earth, and by the wheel-work is moved round the Sun in the ecliptic represented on the papered board below, in one year, or 365 solar or natural days. To the frame of the wheel-work is fastened a brass wire or index, A, which is moved round by the frame, and serves to shew the Sun's apparent daily change of place in the ecliptic, and also the respective days of the month. The Earth in this instrument, being a new papered globe one inch and an half in diameter, contains the principal divisions of the globe into countries, &c. and is more illustrative than a small ivory ball, for shewing in a conspicuous manner the changes of seasons, lengths of days and nights, &c. to the different inhabitants of the globe. The ivory ball, ☽, represents the Moon, and goes round the Earth from between it and any fixed point at a great distance in 27 days, 7 hours, 43 minutes, or through all the signs and degrees of her orbit, which is called her *periodical revolution;* but from the Sun to the Sun again, or from change to change, in $29\frac{1}{2}$ days nearly, which is her *synodical revolution;* and in that time she exhibits all her phases already described. B is the wire supporting the terminator, or boundary of light and darkness, C, on the globe; the hemisphere next the Sun being the enlightened side, and the other the darkened. E is the support or axis of the globe, inclined from the ecliptic below in the angle of $23\frac{1}{2}$ degrees; by the wheel-work,

this axis is made to preserve its parallelism, or keep its inclination continually fixed to any distant point. F, a brass ring representing the Moon's orbit, and upon which the stem supporting the Moon, ☽, moves; it may be inclined on its diametrical bar, the extremities of which represent the ascending and descending node; and the nodes also are placed in their proper places in the ecliptic, represented by a brass engraved and silvered rim, G, having on it the signs of the ecliptic, and divided to every three degrees; this ring, and the former, are both connected to the same center as the Earth, and the adjustment or rectification of which will be hereafter described. Below these, moves the arm carrying the Moon, the center of which is fixed firmly in a conical socket connected with a pinion below in the frame of wheels. The Moon's arm may be turned in this socket over any place or number on the plate H, which is a brass engraved and silvered plate, shewing the number of the Moon's age and her phases for any age. This plate is screwed to the upper bar of the frame of wheels, and it is by the Moon's arm above, moving over it, that her age and phases are pointed out. I is the winder, or winch, to set the wheelwork into motion; it turns a long rod under the board, on which is an endless screw that works into a wheel that gives motion to the whole frame of wheels above the board; which, when in motion, will exhibit the periodical revolutions of Mercury and Venus, the motion of the Earth round the Sun, the parallelism of the Earth's axis, and the revolution of the Moon round the Earth in her proper time.

The board, I K, on which the machine moves, is thirteen inches in diameter, and a printed paper is pasted on it and varnished; this paper contains the following

circles and tables. The outer circle is the days and months of the year, each day being divided into one-half, or 12 hours: the next circle is that of the degrees and twelve signs of the ecliptic, each degree being divided into one-half, or 30 minutes; these divisions of degrees are contiguous to the divisions of the days, so that for any day of the year the Sun's place in the ecliptic may be found by inspection, and *vice versa*. The ecliptic also represents the Sun's apparent annual course in the Heavens; but these particulars I have already described, as belonging to the smaller Orrery. The next circle contains the thirty-two points of the compass. The next circle, that of the azimuths; and the inner one, the amplitudes: as these two last are only used when the paper is applied as the horizon of a globe, I shall not give any description of them here.

On one half of the inner remaining space we have placed a table of the principal affections of the planets; which will be found of considerable assistance to the memory, when any lecture or explanation of the instrument is given, as there is presented at one view the true distances, periodical motions, diameters, &c. &c. of all the primary planets and their satellites. On the other half of the circular space, is given the proportional distances of the planets from the Sun, with the representations of the phases of Saturn's Ring, from 1796 to 1800. See page 12.

Fig. 2 is a representation of an useful appendage to the instrument, which is called the *retrograde apparatus*. It serves to exemplify the apparent retrograde and stationary positions of the planets, as seen from the Earth; and which is the most evident proof of the truth of the present received Copernican System. When a learner

reads, that the planets are in constant and regular motion round the Sun, he is surprized to observe in the Heavens that sometimes Mercury and Venus, particularly the latter, appear for a time to move in the order of the signs of the ecliptic, then to be stationary, and then to move backwards towards the Sun, passing him, to her greatest elongation, and then again to resume her direct motion; but all this is clearly explained by this small apparatus.

A represents a brass hollow stem with an upper fork-shaped termination; this stem is to be placed on the top of the arm, B, of either the planets Mercury or Venus, the ivory ball being first unscrewed therefrom. C is a long brass wire, representing a ray of light coming from the planet denoted by the ivory ball to the Earth. At about *a* there is a small hole, which serves to place it over the pin at the top of the terminating wire of the Earth, C, see *a*, *fig.* 1; the other end of the wire near *b* is to be laid in the fork. Now, it is evident, that when the machine is put into motion, the stem, A, and the wire, C, *fig.* 2, will, by the motion of the arm, B, be carried round the board; and there will be clearly exhibited the following appearances:

When Mercury and Venus are between the Earth and the Sun, they are said to be in the inferior conjunction; when they are beyond the Sun, or when the Sun is betwixt either of them and the Earth, they are in the superior conjunction; in the intermediate situations, or at their greatest distances, as seen from the Earth, they are said to be in their greatest elongations, east or west, as it may be. Now, we will suppose, that the retrograde apparatus is placed to the arm of Mercury, see *fig.* 2, and the planet beyond the Sun in its superior conjunction; the rod, C, to be the ray of light that comes from

the planet to the eye of the spectator: as the Earth and planet are moving round the board, they will both be in direct motion, and Mercury move on in the order of the signs of the ecliptic, till he comes to the greatest elongation, when, his motion for a small space being in the line of the rod, he will appear stationary, as seen in the Heavens; then, as he moves from this elongation to the inferior conjunction and greatest elongation, the ivory ball at the end of the rod, C, will have a retrograde or backward motion through the signs, and exactly as he appears in the Heavens. In this elongation he will again be stationary; and afterwards, till he arrives at the other elongation or opposite point of his orbit, move again in the order of the signs of the ecliptic. As the diameter of the orbits of the planets in the interval of the position of the inferior and superior conjunctions is, from the immense distance, lost to us in the Heavens, these planets can only appear to move in a right line to the east or west of the Sun. When either of these planets is in the node of its orbit, and then in a line with the body of the Sun, it will appear as a round black spot passing over his disc, and is said to be a Transit over the Sun.

From what has been represented, it is clear, that while either of the planets passes from the greatest elongation to the superior conjunction and the other greatest elongation, it appears to move in the order of the signs; and from thence to the inferior conjunction and greatest elongation, it appears in the Heavens to have a retrograde motion, or to move backwards through the signs.

The superior planets, Mars, Jupiter, and Saturn, appear also to have these opposite motions; but can only be exemplified in the Orreries that shew by wheel-work the motions of these planets; and in such instruments

the forked wire, A, *fig.* 2, is only to be placed on the arm of the planet referred to.

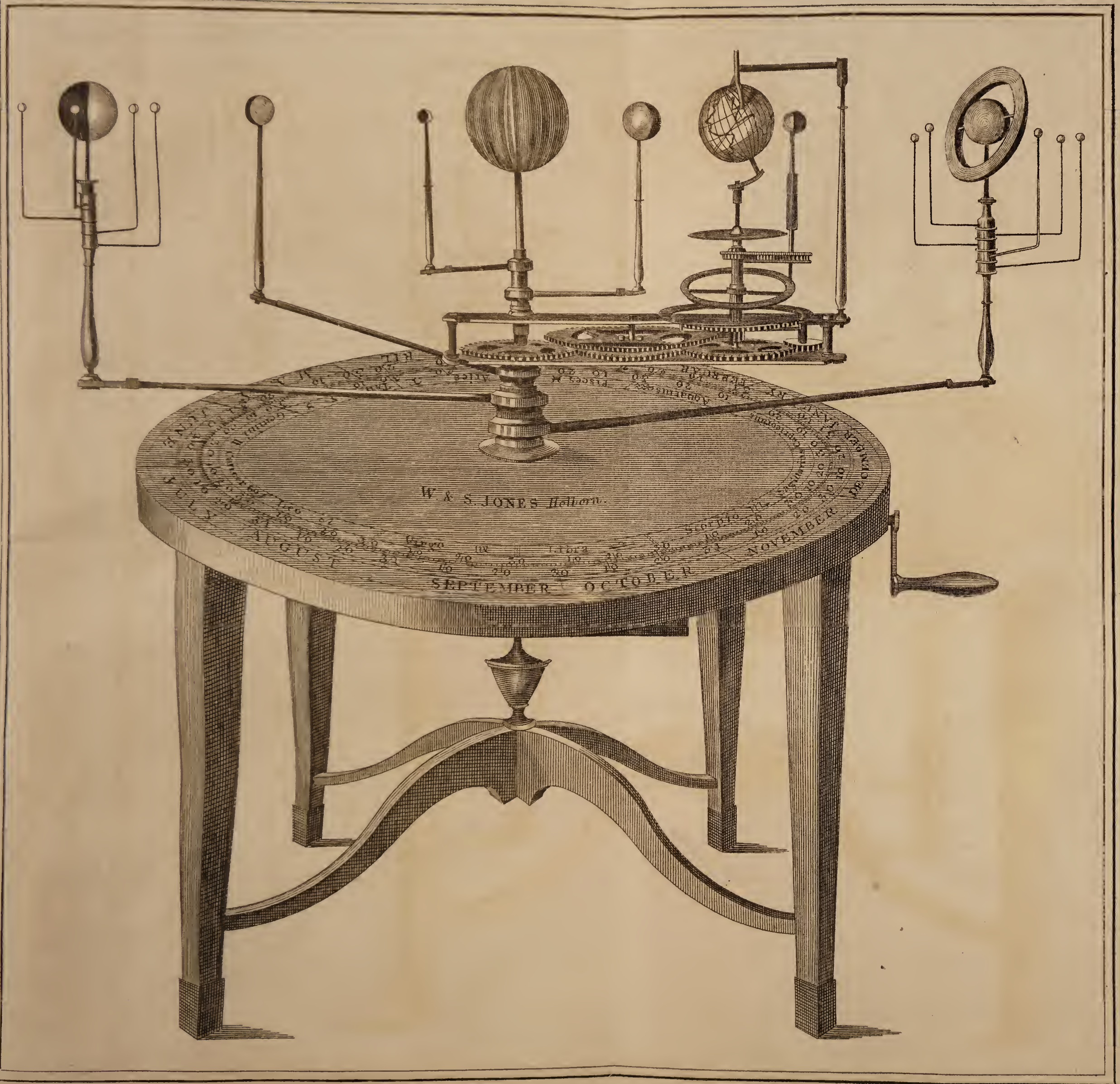
Fig. 3, represents a small lamp to be lighted with a slender wick of cotton and oil, or a wax taper placed in it; it is then to be applied to the center of the Orrery in room of the Sun, which in a darkened room will illuminate the Earth and planets, and convey in a more striking manner the phenomena to the young student.

The simple construction and low price at which this instrument is made, does not admit of its containing the superior planets. To render it more complete, I recommend a small Manual Planetarium, as shewn at *plate* 1, on a board, to accompany it. The whole system in a general and particular way, may thereby be readily illustrated, and the dimensions of the box in which these instruments are packed, is about thirteen inches square and six inches deep.

Plate 4, is a representation of a planetarium, where all the motions of the primary planets are exhibited at one time, by wheel-work, in their respective periodical revolutions, with the parallelism of the Earth's axis for the seasons, and the phases of the moon, and which, as in the heavens, shews the same face constantly to the Earth. The diurnal motion of the Earth, is produced by the hand. The stand is of mahogany, with an ecliptic pasted thereon, coloured and varnished. The diameter either 13 or 16 inches, according to the desired length of the planetary arms. The Georgian planet and satellites are applied, if desired, by an additional arm, to move round and set by the hand for its heliocentric place. Wheel-work is occasionally added to produce the diurnal motion of the Earth.

PLANETARIUM.

PLATE IV.



Printed for W & S. JONES Holborn. 1st September 1812.

Prices of the different Sorts of ORRERIES, *as made and sold by* W. *and* S. JONES, *Holborn.*

	£.	s.	d.
The Tellurian separately, as herein described.....	1	8	0
The Planetarium separately.....	1	8	0
Both the above, packed in a neat mahogany box only $8\frac{1}{2}$ inches square and $4\frac{1}{2}$ inches deep, making the Portable Manual Orrery complete	3	6	0
A larger Orrery, represented in *plate* 3, shewing the motions of the Earth, Moon, and inferior planets, (Mercury and Venus) by wheel-work. The Earth is a $1\frac{1}{2}$ inch papered globe, representing the phenomena of the seasons, &c. thereby more conspicuously. The board on which the instrument moves is 13 inches in diameter.....	4	14	6
With a small Planetarium packed in the same case.....	6	6	0
A Planetarium, shewing the motions of all the primary planets by wheel-work, with $1\frac{1}{2}$ or 3-inch papered globes, (in *plate* 4) according to the wheel-work, and the neatness of the stands, from 7*l.* 17*s.* 6*d.* to	10	10	0
Ditto, with wheel-work, to shew the parallelism of the Earth's axis, the motion of the Moon, her phases, &c.....	18	18	0
Ditto, ditto, with wheel-work, to shew the diurnal motion, on a brass stand in mahogany case.....	22	1	0
A very complete Planetarium, Tellurian, and Lunarium, in three parts, all in brass, shewing by this means the various phenomena in a perfect and perspicuous manner, contrived by the late Mr. B. Martin, packed in a portable mahogany case.....	37	16	0
Box Orreries, with an armillary sphere to circumscribe the planetary motions, from 15*l.* 15*s.* to.....	200	0	0
Cometariums improved, to exhibit by wheel-work, the aspects and motions of Comets.....	5	5	0

ORRERIES *constructed by* W. *and* S. JONES, *upon large, complete, and elegant plans, for the use of public and private scientific seminaries, to any price, according to order.*

NEW GLOBES.

W. and S. JONES think it proper hereby to inform the reader, that there were recently completed two entire new sets of engraved plates, for Globes of eighteen and twelve inches in diameter. The many recent geographical and astronomical discoveries have rendered the old globes inaccurate and obsolete, and new plates indispensably necessary.

On the eighteen inch Terrestrial, are inserted all the latest discoveries from the voyages of Capt. *Cook*, *Vancouvre*, *Perouse*, &c. engraved from an accurate drawing by Mr. *Arrowsmith*, and all the names of the places delineated in a clear and distinct manner. On the Celestial, are depicted the exact places of more than 6000 stars, clusters, planetary nebulæ, &c. communicated by Dr. *Herschel*, and other astronomers, and calculated in position for the present century, or the beginning of 1800, by *W. Jones*. The size of these Globes, which is considered of the dimensions the most manageable, renders them comprehensive of many particulars not to be contained in smaller ones. The graduations of the great circles are to 20 minutes of a degree; and by simple and improved hour circles, the time is shewn to a few minutes. The Globes are so constructed, as in the simplest manner to be capable of all solutions that it is possible for globes to give, and in the English language.

The general prices per pair are from eight to eighteen guineas, as may be seen with figures in *W.* and *S. Jones*'s Catalogue of Instruments annexed to this pamphlet.

The twelve-inch Globes are reduced copies of the above eighteen inches, and contain rather more than half the countries, stars, &c. than are upon the eighteen inches. The graduations of the great circles are to 30 minutes, or half a degree.

The price in plain frames, the pair, is four guineas, and six shillings for the addition of a compass fitted to both horizons of the Globes. In mahogany claw-feet frames, and, with the compasses fixed under the claw-feet, six guineas the pair. In high frames six guineas and an half the pair.

The Globes may be packed securely in packing cases, so as to be safe in conveyance to all parts of the world.

FINIS.

G. WOODFALL, Printer, Angel-court, Skinner-street, London.